



(12) **EUROPEAN PATENT APPLICATION**

(21) Application number : **94308427.7**

(51) Int. Cl.⁶ : **E02F 9/22**

(22) Date of filing : **15.11.94**

(30) Priority : **15.11.93 JP 285161/93**

(43) Date of publication of application :
17.05.95 Bulletin 95/20

(84) Designated Contracting States :
BE DE FR GB

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(54) **Control device for actuator of construction equipment.**

(57) Device for controlling an actuator of construction equipment prevents voiding of a target actuator, by controlling inertia load and power load and reducing heat generated in its return oil channel by means of controlling the aperture of the return oil channel. The device includes directional control valve 14a for controlling a target cylinder 15a of construction equipment. The directional control valve is switched and controlled by a pilot valve 19a which is provided with an operating lever. A meter-out circuit is provided between target actuator 15a and a tank line 16, the meter-out circuit being separated from a meter-in circuit which is connected to control valve 14a. A meter-out valve 32 provided in the meter-out has a throttle position and a large aperture position, the throttle position being adjusted by external signals P_i , corresponding to strokes of the respective operating levers. External signals P_i , for controlling the aperture of meter-out valve 32, are restricted so as not to exceed limiter pressure which is determined by function between the rotation speed of engine 11 which drives the source of hydraulic pressure and degree of operation of operating levers of other actuators.

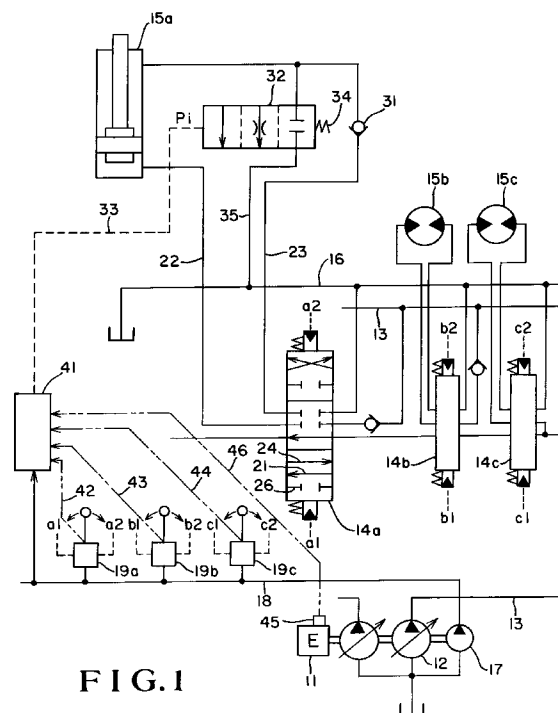


FIG. 1

The present invention relates to control devices for actuators. More particularly, the present invention relates to a control device for an actuator of construction equipment.

In conventional circuits used to control, for example, hydraulic cylinders, providing for stable and continuous operation has proven highly problematic. This difficulty is heightened by the constraints involved in high-speed engine operation. Attempts have been made to solve these problems using known circuits.

Turning now to Figure 5, an example of one of such conventional circuits is shown. An oil feed channel 13 is connected to a discharge port of main pump 12 which is driven by an engine 11. The engine 11 is provided with a plurality of directional control valves 14a, 14b, and 14c.

Working fluid is supplied to actuators 15a, 15b and 15c through the oil feed channel 13. The direction of flow of the fluid is controlled by respective spools of control valves 14a, 14b and 14c. Working fluid discharged from the actuators 15b and 15c returns to a tank line 16, through an oil return channel and control valves 14a, 14b and 14c.

Actuator 15a, a hydraulic cylinder, is the target cylinder to be controlled. Spool valve 14a controls target cylinder 15a. A plurality of pilot valves 19a, 19b, and 19c are attached to a pilot pressure feed oil channel 18.

Oil channel 18 is connected to a discharge port of a pilot pump 17 driven by engine 11, in the same manner as main pump 12.

Each pilot valve 19a, 19b, and 19c is provided with an operating lever. The opening levers associated with each respective pilot valve 19a, 19b and 19c are controlled by an operator of the construction equipment.

Pilot lines a1/a2, b1/b2, and c1/c2 are connected to the respective pilot valves 19a, 19b, and 19c. Pilot lines a1/a2, b1/b2 and c1/c2 are connected to pilot pressure receiving sections of the spools of the corresponding control valves.

In operation, the operating lever of pilot valve 19a is biased in the direction of a1, so that cylinder spool 14a, is shifted through pilot line a1 from the neutral position (as shown in the drawing). This movement of pilot valve 19a, to the working position (the lower oil channel) causes working fluid to be fed from a meter-in oil channel 21, through an oil feed channel 22 to the head end of target cylinder 15a.

At the same time, as a result of the extension of target cylinder 15a, oil is returned through an oil return channel 23, to cylinder spool 14a, and discharged to tank line 16. The oil is returned through an oil return channel 23 to cylinder spool 14a, while being restricted by a return-side throttle 25. The return-side throttle 25 is disposed in a meter-out oil channel 24, at the working position of the spool.

Return-side throttle 25 is provided specially for

cylinder spool 14a. Although the throttle resistance of return-side throttle 25, may be adjusted by controlling the spool stroke, cylinder spool 14a is normally fixed at the full stroke. Cylinder spool 14a, is normally fixed at the full stroke because pressurized oil from main pump 12 is fully supplied through its meter-in oil channel 21, to target cylinder 15a. As a result, meter-in oil channel 21 is fully opened, and a by-pass oil channel 26 is closed. This causes return-side throttle 25 to be fixed at a specified throttle level.

Regardless of the oil feeding quantity of the main pump 12, the quantity of oil supplied by main pump 12 is in proportion to the speed of rotation of engine 11. Thus, regardless of the oil feeding quantity of the main pump, stroke control of cylinder spool 14a is always constant in relation to the degree of operation of the operating lever.

In cases where the engine speed is reduced, or other actuator spool or spools 14b, 14c are operated, an effect is produced similar to the case when the aperture of return-side throttle 25 becomes relatively larger. This is because the aperture of return-side throttle 25 is constant when cylinder spool 14a is set at the full stroke. This is the case in spite of insufficient pump oil feed.

Should inertia load or gravity load of target cylinder 15a be excessively large in this condition, then its cylinder speed will exceed the quantity of oil supply. In this case, the target cylinder is prone to voiding. Further, it may result in temporary stopping and unstable operation. Similarly, control of such poor quality results in high levels of dissatisfaction among users.

Simply making the area of return-side throttle small in order to eliminate the above drawbacks prevents temporary stopping of the system during operation. This occurs at a low engine speed or during interlocking operation with other actuators. However, when target cylinder 15a alone is operated during high engine speed operation, a large quantity of oil is restricted by return-side throttle 25, which results in an enormous loss of heat.

In order to solve the above problem, the present invention controls the aperture of the oil return channel of a target actuator. This controls inertia load and power load, and prevents voiding of the target actuator. Similarly it reduces the calorific value (or heat produced per unit mass due to complete combustion) of the oil channel.

Accordingly, it is an object of the present invention to provide a control device for an actuator for construction equipment to control the aperture of the oil return channel of a target actuator.

It is a further object of the present invention to provide a control device for an actuator for construction equipment which controls inertia load and power load.

It is a still further object of the present invention

to provide a control device for an actuator for construction equipment which prevents voiding of the target actuator and reduces the calorific value of the oil channel.

Briefly stated, there is provided a device for controlling an actuator of construction equipment by means of directional control valves which are modulated by respective operating levers to prevent voiding of a target actuator, of which inertia load and power load are to be controlled, and reduce heat generated in its return oil channel by means of controlling the aperture of the return oil channel.

According to an embodiment of the invention, there is provided a device for controlling an actuator of construction equipment by means of directional control valves which are modulated by respective operating levers, wherein, a meter-out circuit is provided between an actuator to be controlled and a tank line, said meter-out circuit being separated from a meter-in circuit which is connected to said control valves; and said meter-out circuit includes a meter-out valve having a throttle position and a large aperture position, said throttle position being adjusted by external signals which correspond to the strokes of the respective operating levers.

The above, and other objects, features and advantages of the present invention will become apparent from the following detailed description of the present invention.

Fig. 1 is a hydraulic circuit diagram of an actuator control device of construction equipment according to an embodiment of the present invention.

Fig. 2 is a characteristic diagram showing correlation between the area of the spool aperture of a meter-out valve used in the control device and its spool stroke and also showing correlation between said spool stroke and pilot pressure according to an embodiment of the present invention.

Fig. 3 is a diagram illustrating correlation between external signals representing pilot pressure to the meter-out valve and operating stroke of a lever for operating a target cylinder according to an embodiment of the present invention.

Fig. 4 is a diagram illustrating correlation between limiter pressure regarding the above pilot pressure and engine speed which also illustrates correlation between limiter pressure and the maximum strokes of the operating levers for operating the other actuators according to an embodiment of the present invention.

Fig. 5 is a prior art hydraulic circuit diagram of an actuator control device of construction equipment.

Referring to Fig. 1, an oil channel 23 of a target cylinder 15a, which is the actuator to be controlled, is provided with a check valve 31. Oil channel 23 also contains a meter-out valve 32, which is disposed between a location on oil channel 23 and a tank line 16.

Meter-out valve 32 is controlled by using a bal-

ance between the pushing force of a spring 34 and external signals, (for example, pilot pressure P_i , supplied from an external signal line 33). External signals are provided separately from a line for controlling strokes of the spool of a directional control valve 14a.

Directional control valve 14a, controls target cylinder 15a, which spool is hereinafter referred to as cylinder spool 14a.

Unlike a conventional fixed throttle (such as a return-side throttle 25, as shown in Fig. 5), meter-out valve 32, of the present invention has a fully open position where the aperture of the valve is sufficiently large.

Meter-out valve 32 also has an adjustable throttle position during the medium stroke operation, and a fully closed position where the valve 32 is closed by means of spring 34. The meter-out valve 32 is closed by means of spring 34 when there is no pilot pressure P_i .

Thus, there is no need to provide a throttle similar to the one illustrated in Fig. 5. With conventional circuits a meter-out oil channel 24, of cylinder spool 14a, because meter-out valve 32 has the adjustable throttle position and check valve 31 prevents oil return. Therefore, no throttle is provided in meter-out oil channel 24.

As a return line 35 from meter-out valve 32 is directly connected to tank line 16, permitting oil to return there through to the tank, it is not necessary to return the oil to cylinder spool 14a.

Provided between a pilot pressure supply oil channel, which is drawn out from a pilot pump 17, and external signal line 33 of meter-out valve 32 is a pilot pressure controller 41 for controlling meter-out valve 32 according to strokes of the operating levers through external signals (pilot pressure P_i).

Pilot pressure controller 41 includes a signal line 42 for detecting strokes of the operating lever of a pilot valve 19a for the target cylinder and inputting result of detection, signal lines 43/44 for detecting and inputting strokes of the operating levers of respective pilot valves 19b/19c for the other actuators, and a signal line 46 for inputting the engine speed detected by an engine speed detection sensor 45 attached to an engine 11. The function of pilot pressure controller, in other words the method of processing signals input from these signal lines, is explained later in details.

Next, the function of the hydraulic circuit is explained hereunder, within the scope shown in Fig. 1. When cylinder spool 14a is shifted through pilot line 14 from the neutral position shown in the drawing to the extended position (the lower oil channel) by biasing the operating lever of pilot valve 19a in the direction of a1, working fluid is fed from a meter-in oil channel 21 through an oil feed channel 22 to the head end of target cylinder 15a.

At that time, return oil pushed from the rod side together with the extension of target cylinder 15a oil

flows through meter-out valve 32, which is switched and controlled to the throttle position or the fully closed position by means of pilot pressure signals P_i output from pilot pressure controller 41 according to the operation of the lever of pilot valve 19a, and discharged through return line 35 to tank line 16.

When cylinder spool 14a is shifted through pilot line a2 from the neutral position shown in the drawing to the contracted position (the upper oil channel) by biasing the operating lever of pilot valve 19a in the direction of a2, working fluid fed from cylinder spool 14a into oil channel 23 flows through check valve 31 and is directly fed into a rod-side port of target cylinder 15a, thereby putting target cylinder 15a in the contraction mode. During this contraction mode, the oil pushed out of a head-side port of target cylinder 15a is discharged through oil channel 22 and cylinder spool 14a to tank line 16.

Next, meter-out valve 32 and pilot pressure controller 41 are explained, as referred to above in Figs. 2 to 4. As previously explained, Fig. 2 illustrates correlation between the area of the spool aperture of meter-out valve 32 and its spool stroke as well as correlation between spool stroke of meter-out valve 32 and pilot pressure.

Likewise, Fig. 3 illustrates correlation between external signals representing pilot pressure P_i , which corresponds to the pilot pressure mentioned above, and operating stroke of the operating lever of pilot valve 19a for the target cylinder.

Also, Fig. 4 illustrates correlation between limiter pressure which exists in relation to pilot pressure P_i and engine speed detected by sensor 45 as well as correlation between the maximum degree of the strokes of the operating levers of pilot valves 19b/19c for the other actuators and limiter pressure.

Once again, referring to Figs 2 to 4, when target cylinder 15a that is provided with meter-out valve 32 is operated alone, the lever-operating strokes for the other actuators are zero. Therefore, the maximum value on the solid line representing characteristic values of limiter pressure shown in the right graph of Fig. 4 is the limiter pressure actually applied, and a value which is on the upper line (line I) representing limiter pressures corresponding to an arbitrary engine speed is adopted as a limiter value in Fig. 3.

When the other actuators 15b/15c are simultaneously operated, the pressure of the limiter changes according to the degree of the operation stroke of their operating levers in such a manner as to smoothly deviating from the line I towards line II in Fig. 4.

Respective terminal points D' and G' on the upper limit line (line I) and the lower limit line (line II) of limiter pressures are slightly greater in this order than the lower limit (pressure C) for lever modulation shown in Fig. 3.

Next, the controlling method and the function of a meter-out valve according to the invention is ex-

plained, referring to Figs. 2 to 4.

With regard to Fig. 3, the operating lever of pilot valve 19a for the target cylinder is operated within the modulation range between lever stroke points E and F in order to control pilot pressure P_i between pressure point C, which is identical to the valve opening pressure of meter-out valve 32, and pressure point D, which is identical to the full aperture pressure.

At that time, in cases where the engine speed becomes low when the operating lever for target cylinder 15a is operated to the full stroke, i. e. point F, the maximum value of pilot pressure P_i shown in Fig. 3 is limited by limiter pressure defined by line I in Fig. 4. In cases where the engine speed is low and another actuator or other actuators are operated by means of their respective operating levers, the maximum value of pilot pressure P_i shown is also limited by limiter pressure which is determined by either line II in Fig. 4 or intermediate characteristics between lines I and II. Therefore, instead of being fully opened, meter-out valve 32 is maintained at the throttle position corresponding to the limiter pressure as shown in Fig. 2 and consequently prevents voiding of target cylinder 15a which may otherwise be caused by insufficient working fluid.

In cases where the engine speed is high and neither of the other actuators 15b/15c is operated, the limiter value is at point D and identical to the full aperture pressure, wherein meter-out valve 32 is fully open. As a large quantity of oil is able to flow without being throttled, there is no danger of generation of excessive heat loss.

Having described preferred embodiments of the invention with reference to the accompanying figures, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention as defined in the appended claims.

Claims

1. A device for controlling an actuator of construction equipment comprising: a plurality of means for directional control and a meter-in circuit connected to said means for directional control; and characterized by a plurality of signal lines for detecting operation of the respective means for directional control, a meter-out circuit provided between the actuator to be controlled and a tank line and including an adjustable throttle controlled in accordance with the signals from said signal lines.
2. A device for controlling an actuator of construction equipment as claimed in claim 1, wherein

said plurality of means for directional control comprise lever operated pilot valves.

3. A device for controlling an actuator of construction equipment according to claim 2, wherein said signals include signals which correspond to the strokes of said respective operating levers. 5
4. A device for controlling an actuator of construction equipment according to any preceding claim, wherein said throttle is controlled in accordance with the speed of rotation of an engine for driving the hydraulic source and the degree of operation of the operating levers for the other actuators. 10 15
5. A device for controlling an actuator of construction equipment as claimed in claim 4, further comprising:
a pilot pressure controller for controlling said meter-out valve according to strokes of said operating levers and speed of rotation of said engine through external signals. 20
6. A device for controlling an actuator of construction equipment as claimed in claim 5; wherein said device is arranged to prevent voiding of a target actuator, by controlling inertia load and power load and reducing heat generated in a return oil channel, by controlling the aperture of said return oil channel. 25 30

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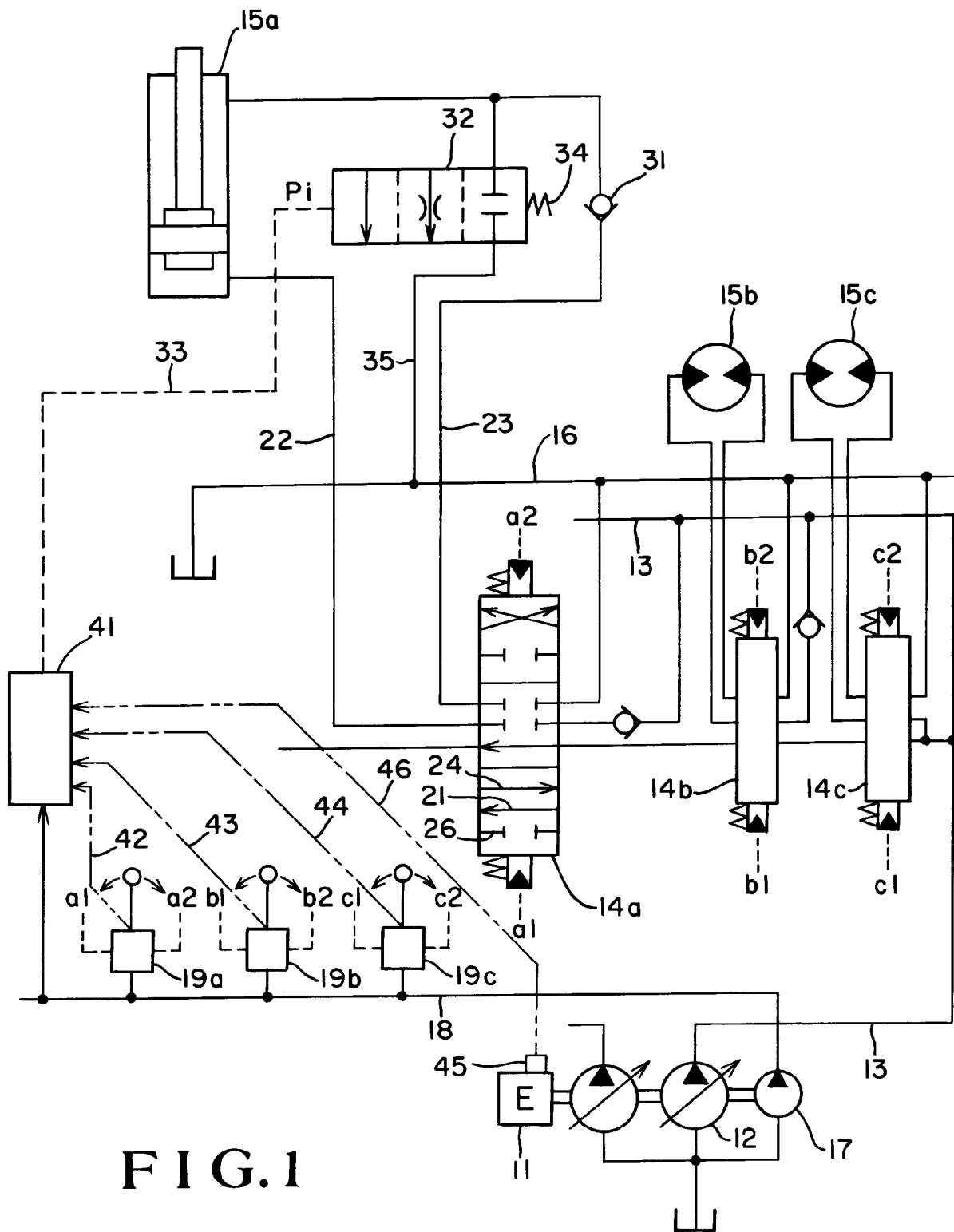


FIG. 1

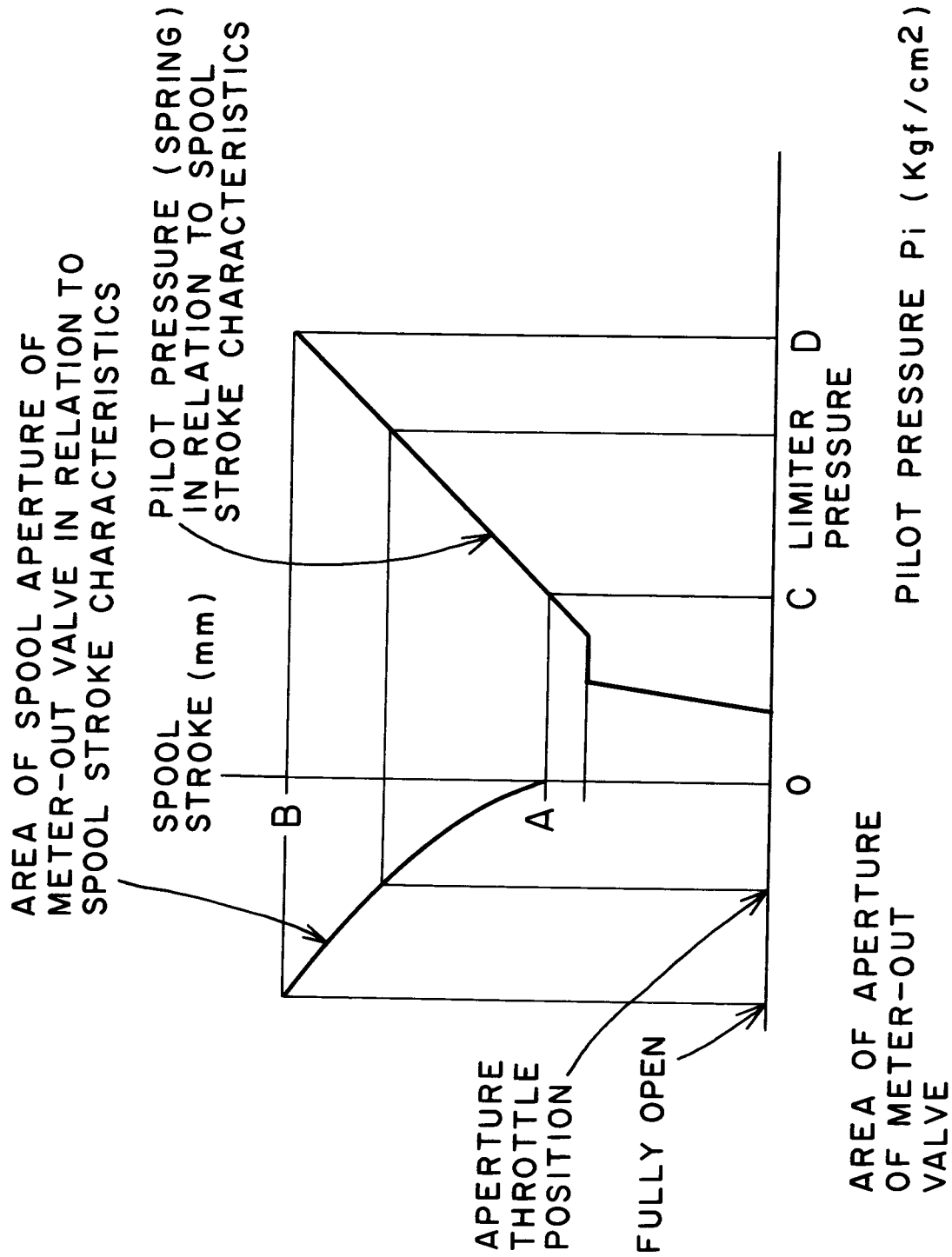


FIG. 2

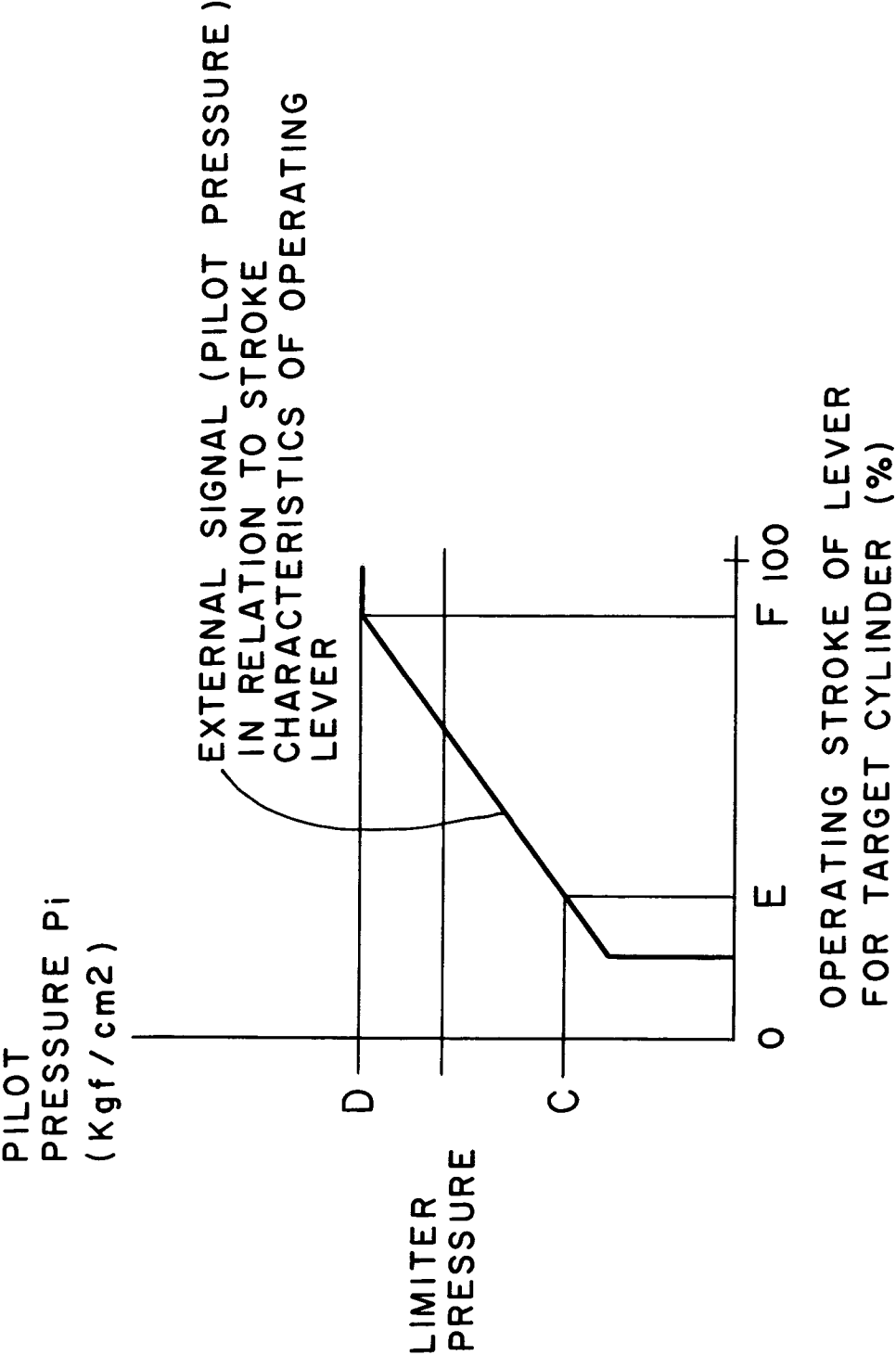
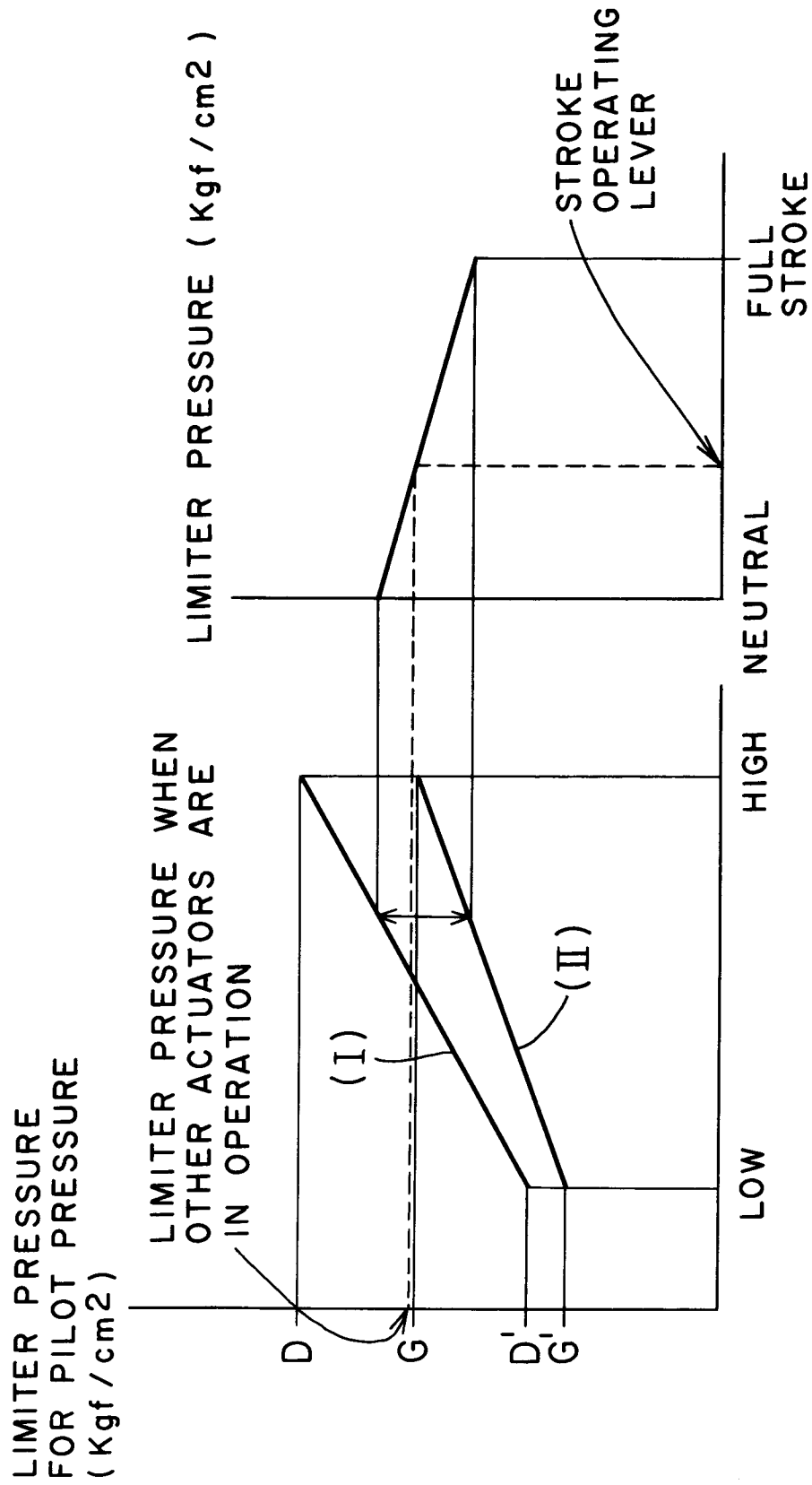


FIG.3



MAXIMUM STROKE OF
OPERATING LEVERS FOR
OTHER ACTUATORS

FIG.4

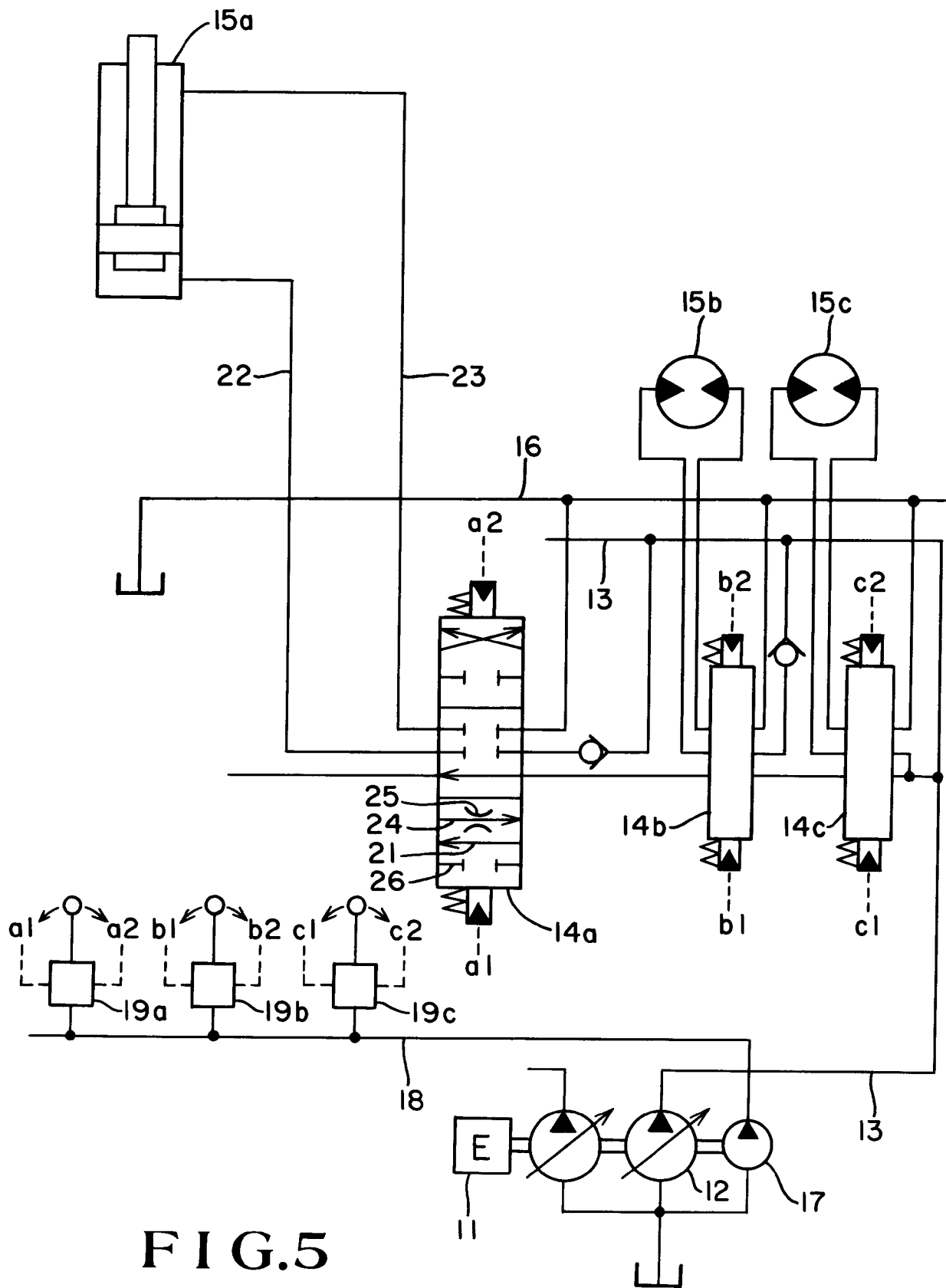


FIG.5



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 94 30 8427

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP-A-0 331 076 (KABUSHIKI KAISHA KOBE SEIKO) * the whole document *	1-3	E02F9/22
A	WO-A-89 02010 (CATERPILLAR INC.) * the whole document *	1-3	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			E02F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 8 February 1995	Examiner Estrela y Calpe, J
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